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ORIGINAL ARTICLE

Prevalence of periodontitis based on retrospective radiographic evaluation at dental hospital in Eastern Province of Saudi Arabia: A retrospective study

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Prevalence

Abstract *Objectives:* The contemporary information on the prevalence of periodontitis and associated risk factors is deficient in the Kingdom of Saudi Arabia. Our aim was to measure the prevalence of periodontitis and associated risk factors among the Saudi population in the Eastern Province of Saudi Arabia who visited the University Dental Hospital.

Methods: In this retrospective study, the demographic data and medical and dental records of 700 subjects were examined. Bitewing radiographs were analyzed to measure the alveolar bone loss in posterior teeth by measuring the distance between the cementoenamel junction and the crest of the alveolar bone. A chi-square test was performed to compare the severity of periodontitis. A comparison of multivariate mean bone loss was performed using a *t*-test. Logistic regression analysis was used to evaluate the predictors of periodontitis. A P-value equal to or under 0.05 reflected statistical significance.

Results: Among 700 cases, the patients' mean age was 35.6 ± 12.1; 52.6 % were male and 47.4 % were female. Overall periodontitis prevalence was 52.1 %. The distribution of mild, moderate, and severe periodontitis prevalence was 36.1 %, 14.1 %, and 1.8 %, respectively. The severity

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of periodontitis was statistically similar between males and females ($p = 0.148$); however, significantly more Saudi than non-Saudi patients had moderate periodontitis. Higher proportions of severe periodontitis were seen in the age group of over 50-years-old ($p < 0.001$) and in patients with poor oral hygiene ($p < 0.001$), diabetes mellitus ($p < 0.005$), and hypertension ($p < 0.002$). Six total predictors of periodontitis were depicted, i.e., age > 50 years (OR = 3.73), poor OH status (OR = 2.24), BOP (OR = 3.35), presence of plaque (OR = 2.61), diabetes mellitus (OR = 3.19), and hypertension (OR = 3.62).

Conclusion: The primary factors associated with the prevalence of periodontitis were age, nationality, diabetes, hypertension, BOP, plaque, and OH status. However, no association was observed between gender or cardiovascular disease and the prevalence of periodontitis in the studied population.

1. Introduction

Periodontal disease (PD) is the infection of the supporting structures around the teeth, which include the gingiva, periodontal ligament, cementum, and bone. It is linked to the formation of a highly pathogenic bacterial biofilm around the teeth, which generates an inflammatory host response. This results in the destruction of the supporting bone around the teeth, leading to subsequent tooth loss (Thomas and Nakaishi, 2006). Host-derived inflammatory mediators released due to increasing bacterial load in periodontal disease play a vital role in promoting systemic diseases (Larvin et al. 2022; Suzuki et al. 2022; Spahr et al., 2006).

Major risk factors associated with periodontitis include age, gender, oral hygiene, smoking status, ethnicity, lower socioeconomic status, and systemic diseases (Nazir. 2017; Madi et al. 2021). The relationships between PD and smoking, cardiovascular disease, diabetes mellitus, and adverse pregnancy outcomes have been reported extensively in the literature (Albandar, 2002a, b; Nazir, 2017). A two-way relationship has been reported between PD and diabetes mellitus. Uncontrolled diabetes mellitus intensifies the risk of periodontal disease, and on the other hand, PD negatively affects patients' glycemic control (Thomson et al., 2004; Humphrey et al., 2008; Preshaw et al., 2012).

PD is considered the major cause of tooth loss in the adult population (Winning and Linden, 2017). It has been reported that approximately 3.5 billion people were affected by oral diseases around the globe, while severe PD was anticipated to affect approximately 14 % of the adult population, denoting more than one billion cases worldwide. (Seattle: Institute of Health Metrics and Evaluation (IHME); 2020). This great worldwide burden of periodontal and oral diseases has a deleterious impact on the overall health, efficiency, and quality of life of the individuals suffering from these diseases (Tonetti et al., 2017; Bernabe et al., 2020).

According to a recent review, the contemporary information on the prevalence of PD and associated risk factors in the Kingdom of Saudi Arabia (KSA) is deficient (Alshammari et al., 2019). It was emphasized by the Saudi national oral health research program that, according to Vision 2030, there is a substantial need to conduct more research related to oral health conditions in the KSA.

Therefore, the present study aims to evaluate the prevalence of periodontitis and associated risk factors among the Saudi population in the Eastern Province of Saudi Arabia, who visited the Imam Abdulrahman bin Faisal University Dental Hospital, which is the leading dental hospital in the region. The primary goal of the present study was to identify the percentage prevalence of periodontitis, while the secondary goal was to identify the relationship between periodontitis and associated risk factors among the Saudi population in the Eastern Province of Saudi Arabia.

2. Materials and methods

Ethical Approval.

The approval for the present retrospective study was obtained from the Institutional Review board of Imam Abdulrahman bin Faisal University (IAU), Dammam, KSA (IRB: 2022–02-219). The study was performed in line with the Helsinki Declaration guidelines.

2.1. Patient selection

The database of the College of Dentistry, IAU Dental Hospital was searched for patients who visited between the period of January 1st, 2018, to 31st December 2020. The patient inclusion criteria were: 1) age of 18 years or above; 2) the presence of complete medical and dental history; 3) bitewing (BW) radiographs being available; and 4) the presence of at least four posterior teeth, two neighbouring teeth in each arch. The patient exclusion criteria in the study were as follows: 1) patients with available BW radiographs were excluded if the CEJ or alveolar bone crest could not be clearly detected; 2) patients without at least two neighboring posterior teeth were excluded; 3) patients with posterior teeth in which the CEJ was not visible due to dental restorations were excluded.

Alveolar crestal bone loss (CBL) was measured on all posterior teeth present in each patient excluding third molars as well as posterior teeth adjacent to an edentulous area since bone loss could be due to surgical trauma.

The tooth with highest CBL was taken to determine the severity of the periodontal disease in a particular patient. Based on Silness & Löe (1964) plaque index, the patient oral hygiene (OH) status was divided into three categories: good, fair, and poor.

2.2. Radiographic examination

In this study, BW radiographs were utilized to measure the CBL. CBL was calculated on posterior teeth in both the mandible and maxilla. ImageJ software (Wayne Rasband, USA, version 1.47) was used to measure the CBL on each tooth (both mesial and distal surface). A BW radiograph of an implant (with the known width of an implant) was utilized to set the scale for the measurement in ImageJ software. This calibration generated a pixel/mm ratio which was utilized to perform CBL measurements (van Eekeren P et al. 2016). All the measurements were calibrated with the same reference radiograph. A straight line was sketched on the mesial and distal surface of the tooth parallel to the long axis from the CEJ to the top of the alveolar bone to measure the CBL (Fig. 1). Distances equal to or > 2 mm between the CEJ and the bone were considered the radiographic sign of interproximal bone loss, as evaluated on a BW radiograph (Zahid et al., 2013; Madi et al. 2021; Osamah H 2018). The primary outcome of the present study was the prevalence of PD in Saudi population who visited the COD hospital in the Eastern province of Saudi Arabia. The prevalence of PD was categorized based on case definition by task force classification from the American Academy of Periodontology (AAP) into mild (CBL > 2 mm ≤ 3 mm), moderate (> 3mm ≤ 5 mm), and severe periodontitis (CBL > 5 mm) (American Academy of Periodontology Task Force Report 2015).

All the radiographic images were examined in a dark room for precise measurements. Three examiners evaluated the images, and inter- and intra-examiner reliabilities were achieved. All the examiners were calibrated by using BW radiographs for 60 randomly selected patients. The measurements for the same patients were recorded two weeks later with the first measurement being blinded.

2.3. Sample size calculation

The sample size calculation was performed by utilizing the Research Advisors (2006); with an error of 5 % and a confidence interval of 95 %. Cochrane's sample size formula was used, and the estimated sample size was 385. However, a much greater sample size (700) was used in the present study.

2.4. Statistical analysis

Data analyses were conducted by SPSS-20.0 (IBM product, USA). Categorical data, including gender, nationality, oral hygiene, and systemic diseases, were presented as frequencies and percentages. A Chi-square test was performed for the comparison of the severity of periodontitis to categorical variables. Numerical data including age and bone loss measurement were depicted as mean ± standard deviation (SD). Bone loss measurements were investigated for normality using the Kolmogorov-Smirnov test, which revealed a normal distribution. A comparison of multivariate mean bone loss was performed by using a *t*-test. Logistic regression analysis was used to evaluate the predictors of periodontitis. A P-value of less than or equal to 0.05 reflected a statistically significant difference.

3. Results

Inter-examiner reliability was evaluated by three examiners by calculating Cronbach's alpha for the item bone loss measurement based on a random selection of 10 % of total measurements, which provided a reliability coefficient of $\alpha = 0.999$, revealing high inter-rater reliability (IRR). Intra-examiner consistency based on a random selection of re-assessments provided an intra-class correlation ICC = 0.989, revealing high internal consistency.

A total of 1056 patient records were examined, with 356 records being excluded due to incomplete patient data or missing bitewing radiographs. Among the remaining 700 cases, male preponderance was found (52.6 % male versus 47.4 % female). There were 470 (67.1 %) Saudi and 230 (32.9 %) non-Saudi nationals. Non-Saudi nationals were mainly from India, Egypt, Pakistan, and the Philippines. The mean age of patients was 35.6 ± 12.1 (ranging from 18 to 72) years. The majority (49.5 %) of the patients had a poor oral health status, followed by 40.7 % who had fair oral health and only 8.9 %

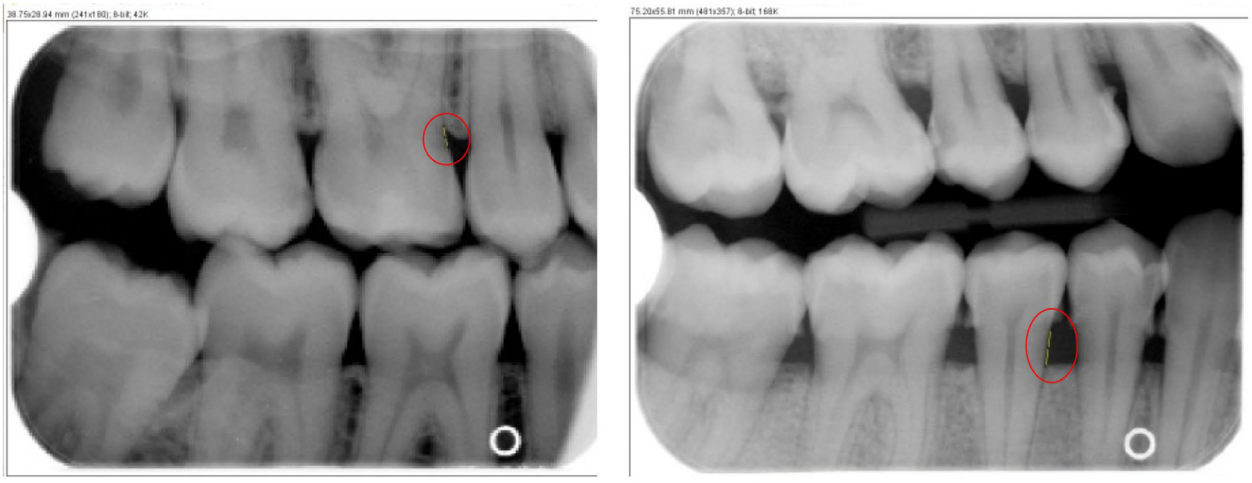

Fig. 1 A Bitewing Radiographs of the patient for alveolar bone loss measurements. A straight line was sketched on the mesial as well as the distal side of the tooth parallel to the long axis of each tooth from the most apical part of CEJ to the most coronal part of the alveolar crest to measure the mean alveolar crestal bone loss as shown in the red circle.

who had a good oral health status. The rate of comorbidities was as follows: 9.2 % for smoking, 7.3 % for diabetes, 1.1 % for coronary vascular disease, and 6.8 % for hypertension. The rate of open contact was 2.9 %, that of overhang was 11.9 %, and that of enamel pearl was 0.2 %. Regarding radiographic bone loss, 312 patients (47.9 %) were normal, 235 (36.1 %) had mild bone loss, 92 (14.1 %) had moderate bone loss, and 12 (1.8 %) had severe bone loss. Thus, the prevalence of periodontitis in the studied sample was 52.1 % (Table 1). The severity of periodontitis was statistically similar between males and females ($p = 0.148$); however, significantly more Saudi than non-Saudi patients had moderate periodontitis. Higher proportions of severe periodontitis were seen in the age group of over 50-yearsold and among those with poor oral hygiene ($p < 0.001$) (Table 1).

Highly significant proportions of patients with diabetes mellitus, hypertension, and BOP were found to have severe periodontitis ($p < 0.005$, $p = 0.002$, and $p = 0.001$, respectively), while the presence of plaque was highly significant among those with moderate periodontitis ($p < 0.001$) (Table 2).

The mean bone loss between males and females was statistically similar ($p = 0.698$); however, the bone loss rate in non-Saudi individuals was significantly higher ($p = 0.003$). There was a highly significant mean bone loss rate in patients older than 50 ($p < 0.001$). The mean CBL was also highly significant among those patients who had poor oral health status, whereas statistically similar mean bone loss was found between smokers and non-smokers ($p = 0.982$). The mean bone loss rate was significant among diabetic ($p = 0.005$) and hypertensive ($p = 0.001$) patients, as presented in Table 3.

Logistic regression analysis was performed to evaluate the predictors of periodontitis; a total of 10 covariates were taken in the panel, and periodontitis was defined as a binary variable. Six total predictors of periodontitis were depicted, i.e., age of over 50 years (OR = 3.73), poor OH status (OR = 2.24), BOP (OR = 3.35), presence of plaque (OR = 2.61), diabetes mellitus (OR = 3.19), and hypertension (OR = 3.62) (Table 4).

4. Discussion

In this study, based on radiographic bone loss, periodontal disease was observed in 52.1 % of the studied population. This contrasts with a previous study conducted in Abha, KSA, which found an overall prevalence of 36.88 % (Zahid et al., 2013). Based on the amount of radiographic bone loss, the current study showed that 36 % of participants had mild periodontitis, 13.9 % had moderate periodontitis, and only 1.9 % had severe periodontitis. In comparison, Zahid et al. found a higher prevalence of mild, moderate, and severe periodontitis, with 57.4 % of patients showing mild, 36.6 % showing moderate, and 4.95 % showing severe disease (Zahid et al., 2013). According to the findings, the male population had a higher incidence of periodontal disease and alveolar bone loss compared to female patients. These findings align with previous studies that observed that males were more likely to suffer from periodontitis (Zahid et al., 2013; Osamah, 2018).

The results of this study depicted the fact that the older population has a greater prevalence of PD as compared to younger individuals. These findings are in accordance with many earlier studies (Rheu et al., 2011; Madi et al., 2021;). Various studies have demonstrated that the prevalence of PD increases with age (Nazir, 2017; Helmi et al., 2019). In addition, the severity of periodontal infection also increases with age, and the mean yearly rate of bone loss was 0.28 mm for 70-year-old participants in contrast to 0.07 mm for 25-year-old individuals (Papapanou and Wennstrom, 1989). The higher rate of bone loss in old age is possibly linked to the duration for which the periodontal supporting structures have been exposed to dental plaque (Könönen et al., 2019).

According to our study, no significant relationship was noticed between smoking and CBL, which differs from previous studies that observed a correlation between tobacco use and periodontitis (O ¨ zcaka et al., 2011; Bergstrom, 2014; Leite et al.,2018; Leite et al.,2019). In the present study, the number of smokers included was too small (9 %) to statistically detect any significant differences between smokers and non-smokers. In addition, due to the retrospective study

Table 1 Association of the severity of periodontitis with demographic characteristics.

Demographic characteristics	Severity of periodontitis				Sig.
	Normal (n = 312)	Mild (n = 235)	Moderate (n = 92)	Severe (n = 12)	
Gender					
o Male	173 (55.4)	113 (48.1)	49 (53.3)	9 (75.0)	0.148
o Female	139 (44.6)	122 (51.9)	43 (46.7)	3 (25.0)	
Nationality					
o Saudi	243 (73.0)	158 (62.7)	60 (61.9) *	6 (50.0)	0.011
o Non-Saudi	90 (27.0)	94 (37.3)	37 (38.1)	6 (50.0)	
Age (years)					
o 14 – 30	158 (50.6)	78 (33.2)	17 (18.5)	0 (0)	< 0.001
o 31 – 50	134 (42.9)	114 (48.5)	56 (60.9)	5 (41.7)	
o > 50	20 (6.4)	43 (18.3)	19 (20.7)	7 (58.3) *	
Oral hygiene status					
o Poor	118 (39.3)	130 (56.5)	57 (64.0)	8 (66.7)	< 0.001
o Fair	142 (47.3)	83 (36.1)	27 (30.3)	4 (33.3)	
o Good	40 (13.3)	17 (7.4)	5 (5.6)	0 (0)	

Normal: < 2 mm, Mild: 2–3 mm, Moderate: > 3–5 mm, Severe: > 5 mm, Sig. = Significance.

Table 2 Association of the severity of periodontitis with risk factors.

Risk factors	Severity of periodontitis				
	Normal (n = 312)	Mild (n = 235)	Moderate (n = 92)	Severe (n = 12)	Sig.
Bleeding on Probing					
o **Yes**	203 (65.1)	185 (78.7)	74 (85.1)	11 (91.7) *	< 0.001
o **No**	109 (34.9)	50 (21.2)	13 (14.9)	1 (8.3)	
Plaque					
o **Yes**	132 (42.3)	140 (59.6)	64 (69.6) *	6 (50.0)	< 0.001
o **No**	180 (57.7)	95 (40.4)	28 (30.4)	6 (50.0)	
Smoking					
o **Yes**	25 (8.7)	22 (9.4)	7 (7.6)	1 (8.3)	0.951
o **No**	187 (91.3)	213 (90.6)	85 (92.4)	11 (91.7)	
Diabetes mellitus					
o **Yes**	11 (3.5)	25 (10.6)	8 (8.7)	2 (16.7) *	0.005
o **No**	301 (96.5)	210 (89.4)	84 (91.3)	10 (83.3)	
Cardiovascular disease					
o **Yes**	5 (1.6)	3 (1.3)	0 (0)	0 (0)	0.655
o **No**	307 (98.4)	232 (98.7)	92 (100)	12 (100)	
Hypertension					
o **Yes**	9 (2.9)	20 (8.5)	11 (12.0))	2 (16.7) *	0.002
o **No**	303 (97.1)	215 (91.5)	81 (88.0)	10 (83.3)	

Normal: < 2 mm, Mild: 2–3 mm, Moderate: > 3–5 mm, Severe: > 5 mm.

Table 3 Multivariate mean comparison of alveolar bone loss.

Variables	Categories	CBL (mean ± SD)	Sig.
Gender	o Male	2.30 ± 1.02	0.698
	o Female	2.27 ± 0.80	
Nationality	o Saudi	2.21 ± 0.87	0.003
	o Non-Saudi	2.43 ± 1.00	
Age groups	o 14–30	1.97 ± 0.67	< 0.001
	o 31–50	2.38 ± 0.92	
	o > 50	2.84 ± 1.21	
Oral health status	o Poor	2.47 ± 1.00	< 0.001
	o Fair	2.15 ± 0.84	
	o Good	1.97 ± 0.67	
Smoking	o Yes	2.27 ± 0.93	0.982
	o No	2.27 ± 0.88	
Diabetes mellitus	o Yes	2.64 ± 0.91	0.005
	o No	2.24 ± 1.01	
Cardiovascular disease	o Yes	1.76 ± 0.44	0.110
	o No	2.28 ± 0.92	
Hypertension	o Yes	2.75 ± 0.93	0.001
	o No	2.25 ± 0.92	

CBL = mean crestal bone loss, SD = Standard deviation, Sig. = Significance.

design, the number of cigarettes per day and duration of the smoking habit were not considered.

Periodontitis is an inflammatory disease; the presence of BOP is one of the main predictors of the disease and disease activity at inflamed sites. In agreement with previous studies, the presence of BOP was strongly correlated with periodontitis (Fransson et al., 2008; Gonzalez et al.,2015; Muthukumar et al.,2014; Madi et al., 2021). In addition, a strong correlation has been reported between BOP and plaque accumulation (Gonzalez et al.,2015; Muthukumar et al.,2014). In agreement with previous studies, our results demonstrated that increased plaque accumulation could be considered a risk indicator for developing periodontitis (Listgarten et al., 1988; Timmerman et al., 2006).

The present study's results showed that patients with hypertension (HTN) have greater alveolar bone loss as compared to healthy patients, which is in accordance with previous cross-sectional studies observing an association between periodontitis and HTN. However, no clear evidence is present to show a strong relationship between HTN and periodontitis (Leong et al.,2014; Lucia et al.,2014).

In this study, BW radiographs were utilized to assess CBL. Other diagnostic tools have been used for bone loss detection, such as periapical and panoramic radiographs or cone-beam computed tomography; however, they offer limited diagnostic information (Vaarkamp et al.,2000; Young et al.,2009). Several studies have verified that bitewing radiography remained the best diagnostic tool for crestal bone examination (Ivanauskaite et al.,2006; Akesson et al.,1989; Madi et al. 2021).

There are some limitations to the present study, such as the fact that it was conducted at a single hospital in the region using radiographic bone loss and no other clinical periodontal parameters to assess disease severity. Another limitation is the fact that the study was only concentrated on posterior teeth for radiographic examination, which might have resulted in an underestimation of the prevalence of periodontal diseases when compared to complete mouth periodontal examination (Helmi et al., 2019). In addition, patients were not categorized according to their current disease status, or their ongoing periodontal treatment. Future cross-sectional multicenter studies that include the clinical as well as the radiographic findings with larger sample sizes are recommended.

5. Conclusions

Overall periodontitis prevalence in the studied population was 52.1 %. According to the severity of bone loss, the distribution

Table 4 Predicting factors of periodontitis.

Covariate	Periodontitis (n = 339)	Normal (n = 312)	Odd ratio (95 % C.I)	Sig.
Male gender	171 (50.4)	173 (55.4)	2.12 (0.81–5.61)	0.125
Saudi national	224 (61.9)	243 (73.0)	0.60 (0.44–0.83)	0.002
Age > 50 years	69 (20.4)	20 (6.4)	3.73 (2.21–6.30) *	< 0.001
Poor oral health status	195 (58.9)	118 (39.3)	2.24 (1.63–3.09) *	< 0.001
Bleeding on probing	270 (90.3)	203 (76.3)	3.35 (2.10–5.34) *	< 0.001
Plaque	210 (93.8)	132 (85.2)	2.61 (1.30–5.26) *	0.006
Smoking	30 (9.8)	25 (8.7)	1.14 (0.65–1.98)	0.656
Diabetes mellitus	35 (10.5)	11 (3.5)	3.19 (1.59–6.40) *	0.001
Hypertension	33 (9.9)	9 (2.9)	3.62 (1.70–7.69) *	< 0.001

Logistic regression analysis was performed to evaluate the predictors of periodontitis; a total of 10 covariates were taken in the panel, and periodontitis was defined as a binary variable.
Sig. = Significance.

of mild, moderate, and severe periodontitis prevalence was 36.1 %, 14.1 %, and 1.8 %, respectively. The risk factors that were associated with the prevalence of periodontitis in the studied population were age, nationality, diabetes, hypertension, BOP, presence of plaque, and OH status. However, no association was observed between gender, smoking status, cardiovascular disease, and prevalence of periodontitis in our study population.

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Ethical statement (if yes submit with date and number).

The study approval was obtained from Institutional Review board of Imam Abdulrahman Bin Faisal University, Dammam, KSA (IRB: 2022–02-219). The study was conducted according to the guidelines of the Helsinki Declaration. Date: 2022.

Uncited references

Global Burden of Disease Collaborative Network (2020), Ozçaka et al. (2011), Silness et al. (1964).

References

Akesson, L., Rohlin M., H‚àöokansson, J., H‚àöokansson, H., N ‚àö¬ßsstro‚àö‚àÇm, K., 1989. Comparison between panoramic and posterior bitewing radiography in the in the diagnosis of periodontal bone loss. J Dent.17, 266-71.

Albandar, J.M., 2002a. Periodontal diseases in North America. Periodontol 2000. Denmark. 29, 31–69.

Albandar, J.M., 2002b. Global risk factors and risk indicators for periodontal diseases. Periodontol 2000. Denmark. 29, 177–206.

Alshammari, A.K.S., Wahi, M.M., 2019. A Narrative Review of the Prevalence of Periodontitis in Saudi Arabia: A Proposal for a National Oral Health Research Agenda for Vision 2030. Open. Dent. J. 13 (1), 171–176.

Bergstrom, J., 2014. Smoking rate and periodontal disease prevalence: 40-year trends in Sweden, 1970–2010. J. Clin. Periodontol. 41, 952–957.

Bernabe, E., Marcenes, W., Hernandez, C.R., Bailey, J., Abreu, L.G., Alipour, V., Amini, S., Arabloo, J., Arefi, Z., Arora, A., et al, 2020. Global, regional, and national levels, and trends in burden of oral conditions from 1990 to 2017. J Dent Res. 99, 362–373.

Fransson, C., Wennström, J., Berglundh, T., 2008. Clinical characteristics at implants with a history of progressive bone loss. Clin. Oral Implants Res. 19, 142–147.

Global Burden of Disease Collaborative Network, 2020. Global Burden of Disease Study 2019 (GBD 2019). Institute of Health Metrics and Evaluation (IHME), Seattle. Available from http://ghdx.healthdata.org/gbd-results-tool.

Gonzalez, S., Cohen, C.L., Galván, M., Alonaizan, F.A., Rich, S.K., Slots, J., 2015. Gingival bleeding on probing: relationship to change in periodontal pocket depth and effect of sodium hypochlorite oral rinse. J Periodontal Res. 50, 397–402.

Helmi, M.F., Huang, H., Goodson, J.M., Hasturk, H., Tavares, M., Natto, Z.S., 2019. Prevalence of periodontitis and alveolar bone loss in a patient population at Harvard School of Dental Medicine. BMC Oral Health 19, 254–259.

Humphrey, L.L., Fu, R., Buckley, D.I., Freeman, M., Helfand, M., 2008. Periodontal disease, and coronary heart disease incidence: a systematic review and meta- analysis. J Gen Intern Med United States. 23, 2079–2086.

Ivanauskaite, D., Lindh, C., Rangne, K., Rohlin, M., 2006. Comparison between Scanora panoramic radiography and bitewing radiography in the assessment of marginal bone tissue. Stomatologija. 8, 9–15.

Könönen, E., Gursoy, M., Gursoy, U.K., 2019. Periodontitis: A Multifaceted Disease of Tooth-Supporting Tissues. J Clin Med. 31, 1135.

Larvin, H., Kang, J., Aggarwal, V.R., Pavitt, S., Wu, J., 2022. Systemic Multimorbidity Clusters in People with Periodontitis. J Dent Res. 101 (11), 1335–1342.

Leite, F.R.M., Nascimento, G.G., Scheutz, F., López, R., 2018. Effect of Smoking on Periodontitis: A Systematic Review and Meta-regression. Am J Prev Med. 54, 831–841.

Leite, F.R.M., Nascimento, G.G., Baake, S., Pedersen, L.D., Scheutz, F., López, R., 2019. Impact of Smoking Cessation on Periodontitis: A Systematic Review and Meta-analysis of Prospective Longitudinal Observational and Interventional Studies. Nicotine Tob Res. 19, 1600–1608.

Leong, X., Ng, C., Badiah, B., Das, S., 2014. Association between Hypertension and Periodontitis: Possible Mechanisms. Sci. World J., 1–11

Listgarten, M.A., 1988. The role of dental plaque in gingivitis and periodontitis. J Clin Periodontol. 15, 485–487.

Lucia Macedo, P.M., Fernando Vilela-Martin, J., 2014. Is there an association between periodontitis and hypertension? Current cardiology reviews. 10, 355–361.

Madi, M., Tabasum, A., Elakel, A., Aleisa, D., Alrayes, N., Alshammary, H., Siddiqui, I.A., Almas, K., 2021. Periodontal risk assessment in a teaching hospital population in Saudi Arabia's Eastern Province. Saudi Dent J. 33, 853–859.

Muthukumar, S., Anand, M.V., Madhankumar, S., 2014. Relationship between gingival bleeding and anaerobic periodontal infection assessed by BANA (N-Benzoyl-DL-Arginine-β-Napthylamide) assay. J Pharm Bioallied Sci. 6, 70–73.

Nazir, M.A., 2017. Prevalence of periodontal disease, its association with systemic diseases and prevention. Int. J. Health. Sci. 11, 72–80.

Osamah, H., 2018. Assessment of periodontal status among the outpatients attending private university dental clinics in Riyadh city. Saudi Arabia. J. Int. Oral Health. 10, 192–197.

Ozçaka, O., Biçakci, N., Pussinen, P., Sorsa, T., Köse, T., Buduneli, N., 2011. Smoking and matrix metalloproteinases, neutrophil elastase and myeloperoxidase in chronic periodontitis. Oral Dis. 17, 68–76.

Papapanou, P.N., Wennstrom, J.L., 1989. Radiographic and clinical assessments of destructive periodontal disease. J. Clin. Periodontol. 16, 609–612.

American Academy of Periodontology Task Force Report on the Update to the 1999, Classification of Periodontal Diseases and Conditions. 2015 J Periodontol. 86, 835-838.

Preshaw, P.M., Alba, A.L., Herrera, D., Jepsen, S., Konstantinidis, A., Makrilakis, K., et al, 2012. Periodontitis and diabetes: a two-way relationship. Diabetologia Germany. 55, 21–31.

Rheu, G.B., Ji, S., Ryu, J.J., Lee, J.B., Shin, C., Lee, J.Y., Huh, J.B., Shin, S.W., 2011. Risk assessment for clinical attachment loss of periodontal tissue in Korean adults. J Adv Prosthodont. 3, 25–32.

Silness, J., Loe, H. Periodontal disease in pregnancy. II. 1964. Correlation between oral hygiene and periodontal condition. Acta Odontol Scand. 22:121–135.

Spahr, A., Klein, E., Khuseyinova, N., et al, 2006. Periodontal infections and coronary heart disease: role of periodontal bacteria and importance of total pathogen burden in the Coronary Event and Periodontal Disease (CORODONT) study. Arch Intern Med. 166, 554–559.

Suzuki, S., Yamada, S., 2022. Epigenetics in susceptibility, progression, and diagnosis of periodontitis. Jpn Dent Sci Rev. 58, 183–192.

Thomas, J.G., Nakaishi, L.A., 2006. Managing the complexity of a dynamic biofilm. J Am Dent Assoc. 137, 10S–15S.

Thomson, W.M., Slade, G.D., Beck, J.D., Elter, J.R., Spencer, A.J., Chalmers, J.M., 2004. Incidence of periodontal attachment loss over 5 years among older south Australians. J Clin Periodontol. United States. 31, 119–125.

Timmerman, M.F., Van der Weijden, G.A., 2006. Risk factors for periodontitis. Int. J. Dent. hygiene. 4, 2–7.

Tonetti, M.S., Jepsen, S., Jin, L., Otomo-Corgel, J., 2017. Impact of the global burden of periodontal diseases on health, nutrition, and wellbeing of mankind: a call for global action. J. Clin. Periodontol. 44, 456–462.

Vaarkamp, J., ten Bosch, J.J., Verdonschot, E.H., Bronkhoorst, E.M., 2000. The real performance of bitewing radiography and fiber-optic transillumination in approximal caries diagnosis. J Dent Res. 79, 1747–1751.

van Eekeren, P., Tahmaseb, A., Wismeijer, D., 2016. Crestal bone changes in macrogeometrically similar implants with the implant-abutment connection at the crestal bone level or 2.5 mm above: a prospective randomized clinical trial. Clin Oral Implants Res. 27 (12), 1479–1484.

Winning, L., Linden, G.J., 2017. Periodontitis and systemic disease: association or causality? Curr oral heal reports. Switzerland. 4, 1–7.

Young, S.M., Lee, J.T., Hodges, R.J., Change, T.L., Elashoff, D.A., White, S.C., 2009. A comparative study of high-resolution cone beam computed tomography and charge-coupled device sensors for detecting caries. Dentomaxillofac Radiol. 38, 445–451.

Zahid, H., Hytham, F., Mohamed, E., 2013. Prevalence of Periodontal Diseases among Patients Attending the Outpatient Department at the College of Dentistry, King Khalid University, Abha. Saudi Arabia. City Dent. Coll. J. 10, 9–12.